

THE PATHOLOGY OF FRACTURE OF THE LOWER EXTREMITY OF THE RADIUS.

BY FREDERIC J. COTTON, M.D.,

OF BOSTON, MASS.

(Concluded from page 218.)

VII. *Fractures of the Radial Styloid* occur, and may be either in the form of an oblique fracture downward into the joint, or of a simple breaking away of the styloid process as such, or of a part of it, in which case the fracture line may be nearly transverse.

Specimens of the first class are reported and described by Callender, St. Thomas Hospital Museum, B16; School of Physic, Trinity College Museum, 291, described by Bennett, plate by Roberts; Hunt (see Fig. 20).

Instances of the breaking off of the process alone are less uncommon. Bennett (united specimen); Guérin, autopsy (cited by Schmit); Warren Museum, No. 4631 (Fig. 19); Packard, specimen in Wistar-Horner Museum; Callender, London Hospital Museum, no number; Middlesex Hospital Museum, I, 23c; Letenneur, autopsy; Power, King's College Hospital Museum, No. 643.

Helferich gives a plate of a case—original observation—where the tip of the styloid alone is separated; this, however, is exceptional, was evidently the result of traction, and is not fairly to be classed as a feature of Colles's fracture.

The fractures of the radial styloid may differ little from the more usual forms as seen clinically, but there seems a tendency in these cases to displacement outward rather than backward. This may be extreme, as in a couple of cases mentioned by Hamilton, in which the apparent lesion was an ob-

lique splitting off of the styloid with extreme displacement upward and outward. He thought this displacement due to

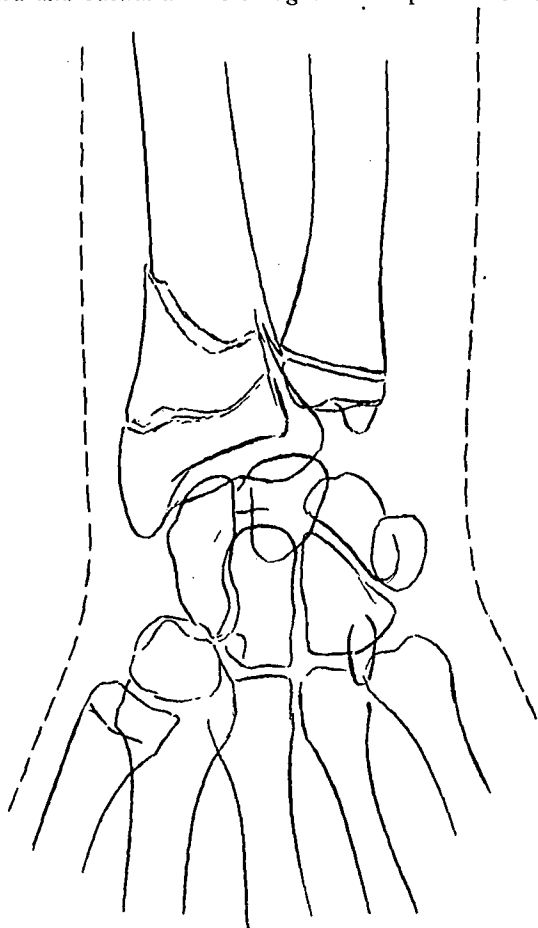


FIG. 16 (X-ray tracing).—Fracture of the radius above the epiphyseal line oblique upward and outward—after reduction; epiphyses of radius and ulna ununited.

the action of the supinator longus; but it seems quite as likely that this position is simply retained by the muscles after the

force splitting off the fragment has carried it upward. At all events, the pull of the supinator longus on a small fragment does not necessarily cause such displacement; in the specimen reported by Bennett some actual displacement inward is evident.

As will be noted later, there seems to be an essential difference in mechanism between this group of fractures and those of the last group as contrasted with the more usual forms of Groups I and II, and III and V.

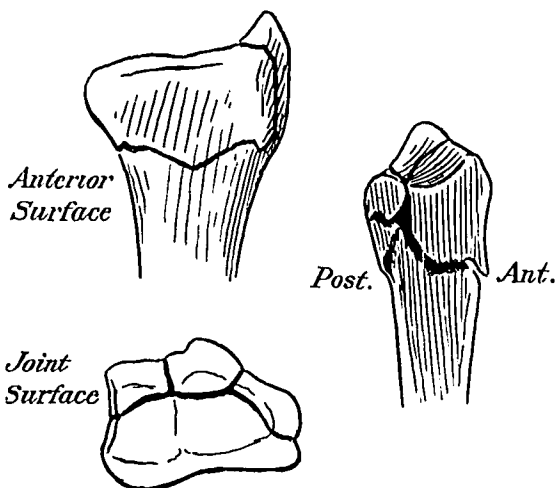


FIG. 17.—Fracture showing lines of comminution into joint; plane of fracture nearly transverse; backward displacement; some crushing and loss of substance at the back (after McGraw and Walker).

VIII. *Fractures Oblique Downward and Outward.*—These are very unusual, whether as a fracture running obliquely through the whole bone, or as a splitting away of a fragment at the ulnar side alone. Of the first sort, Bennett describes a specimen in the Museum of the School of Physic in Trinity College, No. 695, of which Roberts gives an excellent plate, showing an obliquity of about thirty degrees downward and outward; Gordon gives a plate (his Fig. 6) of

a like specimen; there is no great displacement or rotation in any direction. Hennequin cites a case by Poirier where the obliquity in this direction was obvious clinically, and Haughton (his Case I) shows in a skiagraph a like lesion; so, too, Picard (his Observ. II). Smith describes a specimen (his Case XI) in which there was slight obliquity of the line of fracture in this direction. Specimen 3776 of the Warren

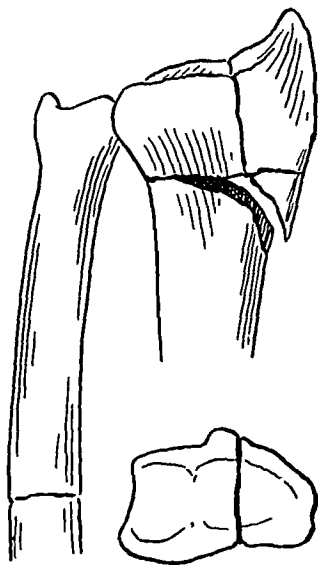


FIG. 18.—Combination of transverse and oblique fracture lines; antero-posterior split into joint; fracture of shaft of ulna. Anterior view (after Westbrook's plate).

Museum shows a splitting away at the ulnar side as well as at the back (see Fig. 10), oblique in this direction.

Splitting away of the ulnar portion of the radius alone is also noted by Packard in the specimen numbered 128 in the New York Hospital Museum. Hall reports a clinical case, pretty clearly of this form. Bardenhauer speaks of a specimen showing a small portion separated, apparently torn away from the radius by the radio-ulnar ligaments.

A small fragment may be split away from the ulnar side



FIG. 19.—Fracture of radial styloid; separation of ulnar styloid at its base; from direct violence. Warren Museum, No. 4631.

of the lower fragment in a transverse fracture, as in the specimen in the Warren Museum, No. 1038. (Fig. 9.)

Kahleyss notes a like case shown by the X-ray (his Tafel VI, No. 9).

IX. *Cracks and Splits of the Radius not Penetrating the Width of the Bone.*—These may be apparently in any direction; but the recorded cases and specimens show either longitudinal splits or cracks running nearly transversely.

The first class is best known through the much-quoted specimen presented to Warren Museum by Dr. Bigelow (No.

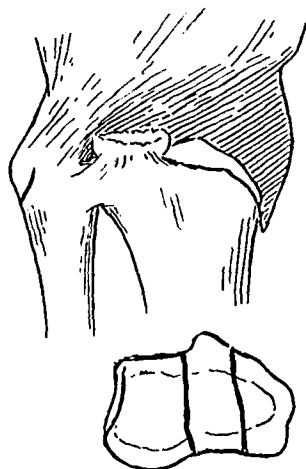


FIG. 20.—Comminuted fracture running obliquely down and inward into the joint; fracture of the semilunar bone; partial fracture of ulnar styloid (after Hunt's plate). Anterior view and view of lower end.

1035, shown in Fig. 21), described by him in the *Boston Medical and Surgical Journal*, Vol. lviii, p. 99. In this specimen there is no transverse fracture, though one relatively small fragment is chipped or rather slivered off. Pilcher figures a similar specimen from the New York Hospital Museum (his Fig. 20).

Bennett figures a specimen in the Museum of the Royal Academy of Ireland showing similar cracks.¹ In this case

¹ British Medical Journal, 1892, i, 903.

the clinical history is recorded; the fracture was caused by the wrist being caught in machinery; and it seems very likely, according to Bennett's experiments, that direct violence is the cause of this particular lesion. Crushing with a boot-heel gives such lesions on the cadaver, and there is no evidence to support Bigelow's theory of the wedge-action of the carpal bones as the cause.

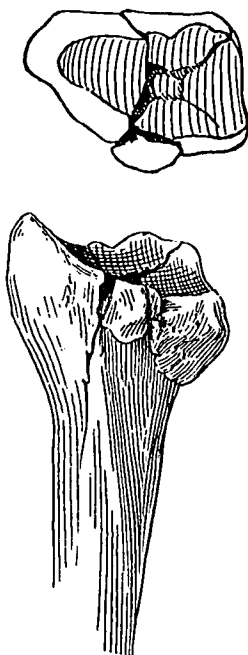


FIG. 21.—Dr. Bigelow's specimen of fissure of the radius. Warren Museum, No. 1035.

The transverse fissures, on the other hand, would seem to be a result of the same violence that produces the ordinary transverse fracture, acting in less degree.

The writer has lately met with five cases of this type (skiagraphs of two of these are given in Figs. 22 and 23). In these cases the cause seems to have been a fall on the palm,

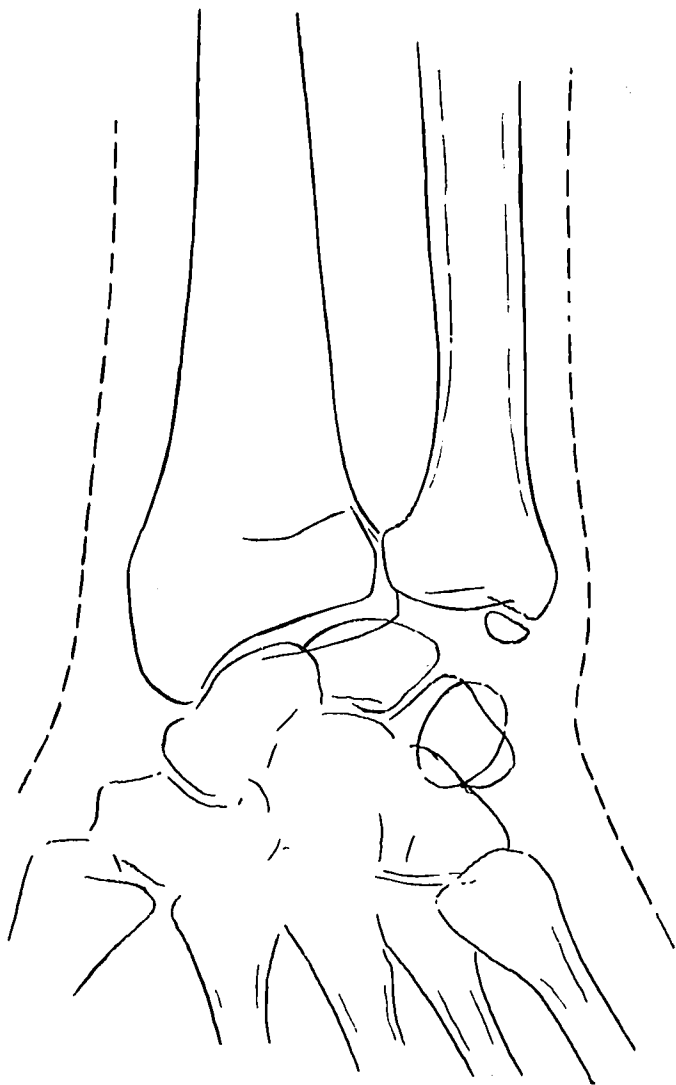


FIG. 22 (Tracing from X-ray negative).—Fissure across inner portion of the radius only; fracture of the ulnar styloid process.

save for one where there was clearly a fall on the ulnar side of the hand. In all five there was sharply defined tenderness at the position of the crack; in no case was there any dis-

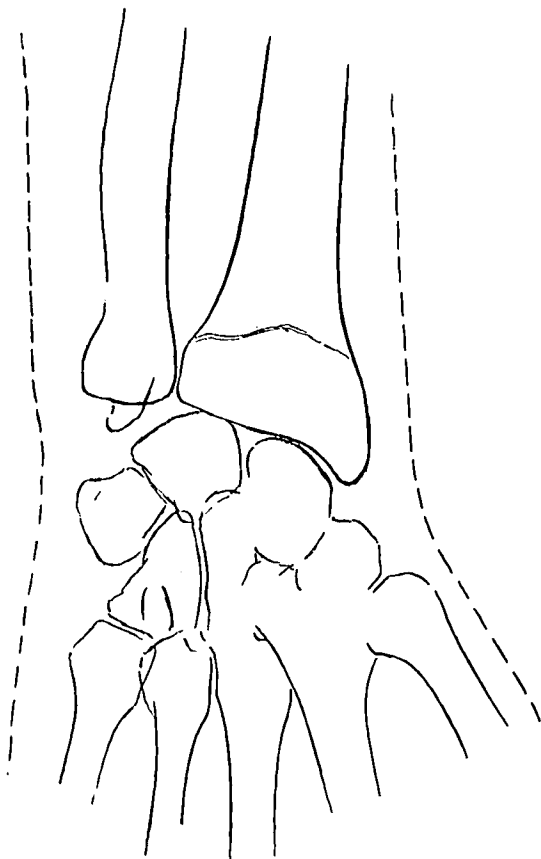


FIG. 23 (X-ray tracing).—Fissure of radius (or possibly transverse fracture without displacement).

placement; in one case there was associated fracture of the ulnar styloid.

As to other recorded cases Packard recognized the possi-

bility of transverse fissure in 1879, while Kahleyss quotes Bruns as recognizing their occurrence, and gives skiagraphs, or rather diagrams from skiagraphs, of two cases of his own belonging to the latter class—the transverse.

There seem to be no data for estimating the actual frequency of longitudinal fissures; they are apparently rare. The transverse cracks are distinctly less unusual; and it would seem that it should be possible to make the diagnosis provisionally by direct examination from the sharply localized tenderness—definitely by means of the X-ray. The writer is inclined to think that careful routine examination of sprains of the wrist from falls on the hand may show a fair proportion of such lesions.

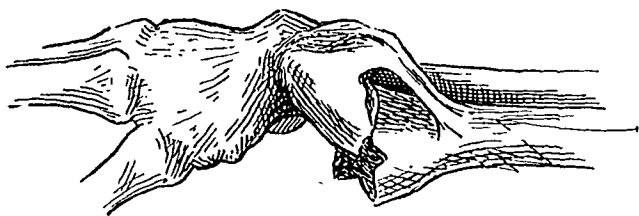


FIG. 24.—Fracture with backward displacement and backward rotation. Shows the stripping up of the untorn periosteum posteriorly (after Westbrook's plate).

There may be other lesions of the radius than those already described, occurring either as an accompaniment of the type fracture or as an independent result of apparently similar trauma. Bennett and Moore each describe autopsy cases where a fracture of the radial shaft higher up accompanied a Colles's fracture. See also a specimen by Dupuytren, quoted by Packard, and the specimen in Warren Museum, No. 1038. Also an autopsy by Cock showed the same lesion, and one by Di Paoli, a greenstick fracture at the middle of the radius with separation of the lower radial epiphysis. The fracture of the radius at the middle third occurring from falls on the hand, apparently in a sense as an equivalent of Colles's fracture, is not extremely rare. Falkson, for example, gives three such cases.

To complete the list of lesions of the radius, Bennett reports a case of *necrosis* of the lower radial fragment in Colles's from unknown cause, and Packard a necrosis of the radial styloid alone, not involving the whole epiphysis. Necrosis in compound suppurative cases has been frequently reported. Abscess from simple fracture has occurred as well as from simple epiphyseal separation.

Lesions of the Carpal Bones seem, in the light of skiagraphs, to be less rare clinically than most clinicians had supposed. Actual anatomical demonstrations of these fractures as accompaniments of Colles's fracture have not been lacking.

Hunt's autopsy report gives a description and plate of a fracture of the semilunar, accompanying an oblique fracture of the radius into the joint. (Fig. 20.)

Kahleyss gives a case of semilunar fracture with Colles's, —a skiagraph. Weir has produced the same thing experimentally.

Fractures of the os magnum with radial fracture have been described, according to Kahleyss, by Bardenhauer. Wight saw at autopsy in one case a piece broken out of the cuneiform. Destot and Gallois produced such fractures experimentally.

The relatively frequent carpal fracture in relation to Colles's is, however, that of the *scaphoid*, a number of cases of which have been described lately, while a considerable number of anatomical specimens are on record: Rutherford, autopsy; D'Arcy Power, St. Bartholomew Hospital Museum, No. 924; Fortunet (recent specimen, quoted by Hoffa), and Flower, Middlesex Hospital Museum, I, 23c, record such cases verified by autopsy. Flower also records a specimen where there was a Colles's fracture and a partial fracture of the scaphoid.

Interesting in this connection is a case cited by Cameron of total dislocation forward of the scaphoid with typical Colles's fracture. An interesting case (reported by Letenneur, quoted by Stimson) was that of a patient who fell, striking both hands and fractured the radius on one side, the scaphoid on the other.

This suggests that the scaphoid fracture may be in some

sense equivalent to the radial fracture, at least a result of like forces. The writer has recently had under his care a case of fractured scaphoid where there was no radial fracture, and yet the history was of a fall on the palm. Such cases seem not very rare. King reports a scaphoid dislocation without fracture, likewise from a fall on the palm.¹

Kahleyss has called attention to the association of scaphoid fracture with fractures of the radial styloid, and points out that in two of the three cases included in his skiagraphic series the line of fracture across the neck of the scaphoid is nearly continuous with the line of fracture of the radius, and in Hunt's case of semilunar fracture the same continuation of the line of fracture is obvious. (See Fig. 20.)

It may be that the fracture of the scaphoid is a result of forced abduction, or, as Destot and Gallois conclude from their studies, of the reception of the impact of the fall by the scaphoid, which, as they point out, is vertical to the ground when weight is borne on the palm.

Lesions of the Ulna, of the Bone itself.—The most common is the fracture of the styloid process, but other fractures do occur.

(1) Fracture of the shaft. Such a fracture may occur at any point, more usually well above the radial fracture, most often about two inches above the wrist. It is a question in some cases whether such fractures may properly be classed as Colles's, but they seem in many cases to be the resultant of similar forces, and, as far as the radial fracture goes, show no distinctive features.

The cases of Westbrook (Fig. 18); Moore (2); Butler; Callender (2); Bruns; Kahleyss (four skiagraphs); D'Arcy Power, London Hospital Museum (Gbi-6), all cite such specimens or X-rays; while this fracture as a complication of separation of the radial epiphysis is instanced by the dissected cases of Roux; Di Paoli (four cases), Hilton, Boeckel, Hartmann, Smith, Bennett, Labadie-Legrance, and a specimen in St. Bartholomew Hospital Museum. In all these specimens

¹ ANNALS OF SURGERY, Vol. xxx, 1899, p. 213.

the ulnar fracture seems to be low down, often very near the epiphysis. A like case is shown in Fig. 25.

In this connection may be mentioned a type of fracture occurring in small children, where both bones give way above the epiphyseal lines in a greenstick or a complete fracture, with displacement backward, or without any considerable displacement. The writer has recently had an opportunity to examine two such cases, and has seen besides these several skiagraphs of similar lesions,—of fractures approximately transverse of the radius and ulna at about the same height, well clear of the epiphyseal lines. These fractures are apparently due (though the point is hard to determine in young children) to falls on the palm, such as give fracture of the radius alone in adults, or such as may give epiphyseal separations in the child. Wight in one case (a boy of eight) found this type of fracture where the dirt ground into the palm attested the way the fall was received.

Warren Museum specimens 1029 and 1030 are casts of this form of fracture, and 1039 shows sequestra from a like fracture.

Freeman gives a good skiagraph of such a case.

Damage to the head of the ulna is apparently a rare complication, but von Lesser assumed it to be a relatively usual lesion, accounting for limitation of pro- and supination, and with this idea in mind he convinced himself that the lesion was relatively frequent in the specimens preserved in the Pathological Institute at Leipzig. Actual demonstrations of such lesions are, however, rare.

Bennett reports an autopsy which showed with the radial fracture a vertical splitting of the head of the ulna, and cites a specimen in the Hunterian Museum in London as showing like lesions.

Kahleyss showed in the skiagraph a fracture of the ulnar head, and Corson publishes a plate (Case IV) apparently showing a like condition. Helferich figures a specimen with partial fracture across the head of the ulna, with separation of the radial styloid as well, the result of traction; and Hoffa



FIG. 25.—Fracture of the radius; fracture of ulna near the joint; much crushing of bone in the radius; marked outward and upward displacement and rotation; fragments freely movable; delayed union.

is responsible for the statement that a splitting away of a small portion of the head on the volar surface is not infrequent. The writer has found no specimens or record of specimens to substantiate this.

A separation of the ulnar epiphysis is rare as a complication either of the simple separation of the radial epiphysis or of the fracture. Poland lists nine such cases. Of especial interest in this class are one with a partial separation, only, of the ulnar epiphysis (Voillemier, cited by Poland), the other, a separation of the ulnar epiphysis with a vertical fracture splitting it, a case of Di Paoli, of which Poland gives an excellent plate.¹

Fracture of the ulnar styloid, now acknowledged to be a frequent complication, has in the past been a much disputed lesion. Nélaton, Velpeau, Tillmanns, Moore, Hoffa, Bennett, and Lucas long since asserted its frequency, but surgeons of equal authority failed to recognize the fact, and insisted on the infrequency of this complication.

The skiagraph, however, has definitely demonstrated that the lesion is a very common one. Kahleyss in a series of sixty cases of Colles's found this fracture in forty-seven, and a number of short series (*e.g.*, those of Thomas, Freeman, Don, Corson, Haughton) show even higher percentages. In forty-five skiagraphs of unpublished cases which the writer has had the opportunity to examine the fracture is definitely shown in eighteen. Beck in a series of forty-four cases found the fracture in but seven. Evidently, the percentage, as well as the interpretation of the pictures, is subject to much variation. Lucas found the styloid gone in fifteen of twenty-eight specimens he examined.

Of five specimens in the Warren Museum four show this lesion. Bennett calls attention to the fact that the proportion of broken styloids is larger than old museum specimens indicate, for they are often much damaged in maceration.

¹ The specimens, St. Bartholomew Hospital Museum, 931, 932, are described as showing a like lesion, with radial fracture one and a quarter inches up.

Moore in seven cases (autopsies and operations) found fractured styloids in five; Cameron in all of a similar series of five; Bennett in two out of three fresh specimens; Lucas in two cases out of three.

The break may be across the base of the process (Figs. 19, 20), at the middle of its length (Figs. 12, 22), or even of the tip only. Kahleyss divides his forty-seven into fracture of the base, 24; of the tip, 13; incomplete fractures in 10.

Fractures of the process appearing incomplete in the radiograph are by no means infrequent (see Fig. 4); and Moore records a case (separation of the radial epiphysis) where such an incomplete styloid fracture was found at autopsy; Hunt reports the same lesion in Colles's fracture of an adult. (Fig. 20.) In these incomplete fractures the beginning separation seems to be invariably on the inner (ulnar) side.

Skiagraphs rarely show two instead of one distal fragment. This seemingly occurs only in fractures of the tips.

There may be no displacement of the fragment, but, as a rule, it is dragged outward,—often far out of its position: there may be a considerable rotation of the fragment as well as displacement. When the fracture is incomplete the deviation seems to be always outward. One skiagraph is recorded with displacement up and in, and the writer has seen another plate showing displacement directly inward. The fracture of the ulnar styloid does not seem to be associated especially with any of the varieties of the radial fracture. The writer has seen it accompanying transverse fractures without any displacement;¹ and it may be absent in fractures with much comminution and in fractures with considerable outward displacement of the radial fragment, a condition which would naturally be expected to imply a constant giving way of either the styloid or the lateral ligament. (See Fig. 15.)

The lesion may occur with anterior displacement, as is

¹ In Fig. 22 is shown a complete styloid fracture where the radial fracture is represented only by a transverse crack only partly traversing the bone.

evidenced by a specimen cited by Callender (in the Westminster Hospital Museum). Clinically, the lesion is in itself unimportant, and at least hard to recognize without the aid of the X-ray.

Jones claims to have found it by manipulation in five of 105 cases, Golebiewski in three out of forty-five. The writer has never felt able to base more than a suspicion of this lesion on the evidence of simple manual examination.

The importance of the lesion lies in the fact, shown by Moore, that the sharp proximal end may become entangled in the ligaments in such a way as to interfere with reduction. This styloid chisel may also determine the protrusion of the ulna through the skin. Such compound fractures are not very rare. It is possible, also, that the damage to the styloid may explain certain cases of persistent pain about the ulnar head after Colles's; this is, however, by no means certain.

The broken process unites by fibrous union. In the only unmacerated specimen the writer has had an opportunity to examine¹ there was firm fibrous union by a band long enough to permit free play of the distal fragment. Lucas records a case with a separation of two lines. Cameron speaks of a similar specimen with a broken tip of the ulnar styloid, separated from the proximal fragment by a "tiny synovial-like cavity." Roberts refers to a specimen (Mutter Museum, 1277, 60) as "now united to the head of the bone," but does not definitely state that union was bony: all other recorded examinations speak of fibrous union. In the specimen 4631 of the Warren Museum there was recorded, before maceration, firm fibrous union of the styloid.

Lesions of Ligaments—The Internal Lateral Ligament.—The fasciculus of this ligament attached to the ulnar styloid may be torn away, as in specimens recorded by Gerard-Marchant, Moore, and Bennett.

Aside from this is the tearing described by Moore, due

¹ A dissecting-room specimen of united Colles's fracture, examined by courtesy of Dr. Thomas Dwight.

to penetration by the broken ulnar styloid and resulting in an entangling of the broken process with the ligament.

The triangular fibrocartilage may be variously torn. It may be torn loose from its insertion at the base of the ulnar styloid. Moore gives three such cases, Lucas two, Bulteau one case of entire, one of partial separation of this attachment: or the radial attachment may be damaged, as in a second case by Bulteau, another by Callender, St. Bartholomew, III, 89, and two by Lucas; or the cartilage itself may be torn across: Cameron (2); Moore (2); D'Arcy Power (King's College Hospital Museum, 643).

The other radio-ulnar ligaments may be entirely or partly torn away. This lesion seems, in view of the widening of the wrist seen clinically, to be a rather common lesion,—for this widening is too constant to be explained by comminution of the radial fragment, and often too considerable to be explained by inflammatory thickening or rotation of the fragment. According to statistics of the Boston City Hospital,¹ it occurred in thirty-six of thirty-nine cases, measured after union had taken place, and varied from one-eighth to three-eighths of an inch, and in ten of thirty-six amounted to one-quarter inch or more. Moreover, though the X-ray can give no direct evidence as to the condition of the ligaments, yet it is notable that many cases show a decided change of relation in the bones,—a distinct gaping between radius and ulna that is impossible of explanation without assuming a giving way of the interosseous connections. In that other class of cases where there is extreme upward displacement of the whole lower fragment, these ligaments must of necessity be destroyed.

Strangely enough, the actual lesion is not mentioned in most of the autopsy reports. Bulteau, however, notes as follows in one of the cases he autopsied:

“La tête cubitale a également perdu ses attachés avec la partie interne du radius, et n'est plus maintenue au corps que par quelques faisceaux ligamenteux qui semblent faire partie du ligament antérieur de l'articulation.”

¹ Boston City Hospital Reports, Series VII, 1896.

Cameron also notes the tearing away of this connection in two fresh specimens examined by him. The X-ray appearance is well shown in the plate of Case II in Don's article. It is unfortunate that data on this point are not fuller, for the broadening of the wrist, apparently due to this lesion, is clinically, if of more than very moderate grade, often associated with a poor functional result after union of the fracture. In one case of the writer's there was a persistently recurring snap forward of the ulna in supination, apparently due to a loss of the interosseous connections.

Bardenhauer has recorded a case in which he found a fracture as an equivalent of this tearing—a small sliver of the ulnar surface of the radius ripped away—corresponding to the lesion sometimes occurring in Pott's fracture of the ankle.

Periosteum.—The periosteum, torn anteriorly in all cases with any amount of displacement, may be simply stripped up behind, and that for a considerable distance. This is well seen in Fig. 24, and is not confined at all to epiphyseal separations, though common in them. Pilcher has called attention to this relation of the periosteum as a factor increasing the difficulty of replacing the lower fragment.

The relation of the periosteum to the fragments in comminuted Colles's fractures is interesting. It may of course be variously torn; but in a considerable portion of cases the splits that separate the fragments do not involve the periosteum, and the lower fragment is, as a whole, pretty closely held together. This is noted in several autopsy reports already cited, and is verified in producing experimental fractures on the cadaver.

Injuries to nerves are rarely demonstrated. Lucas gives a plate showing the stretching of the ulnar nerve over the head of the ulna, which he blames for the persistence of pain in this region; as a matter of fact, the ulnar nerve seems practically never damaged. Cameron speaks of a case where there was a fractured styloid and torn triangular ligament, where there was actual pinching of the ulnar nerve. The case reported by him of pressure on the median nerve was really due

to the dislocation forward of the scaphoid which accompanied the radial fracture. Brunner gives an account of alleged pressure from the radial callus, giving rise to a so-called "tetanus," which subsided on freeing the nerve from callus. The only case of nerve involvement seen by the writer was one of general atrophy of the whole forearm with change in the electrical reactions,—of unexplained causation not to be directly connected with the typical Colles's fracture, though doubtless due to the accident. After an interval of four months power had returned to the arm and hand, save for a weakness of the thumb in flexion, which persisted for some weeks longer and then disappeared.

Lesions of Vessels.—Injury to vessels of any size seems to be exceptional. One specimen in the Warren Museum (No. 8117), obtained from an amputation for gangrene, where gangrene resulted from a tear of the radial artery by a spur of the upper fragment, seems to be unique.

Hæmorrhage from smaller vessels is common, rarely extensive, and may occur in various situations. The Couper-Hutchinson autopsy disclosed hæmorrhage between the tendon-sheaths, and two cases with hæmorrhage beneath the flexor tendon-sheaths and bleeding into the tendon-sheaths are reported by Cloquet and Bruns; both these cases were epiphyseal separations.

Lesions of the soft parts other than those already mentioned are rare. In a few cases only has *compound fracture* occurred. Lucas reports an autopsy in one such case, as does Bennett. Callender speaks of a compound Colles's fracture followed by gangrene, and Hecht's case was also compound.

Compound separations of the radial epiphysis are considered under that head; for some reason they are far less rare than is the case with the true fracture.

Penetration of the skin by the end of the ulna is not very uncommon, comparatively. Moore describes two such cases, Gaugeot three (quoted by Schmit), Cameron two, and Gerard-Marchant one. Lucas's case cited above showed penetration

of the skin by the radius and ulna through different wounds on the wrist.

Abrasions on superficial wounds opposite the luxated ulnar head on the volar side are of course fairly common.

Gangrene seems (save for the case with torn radial artery above mentioned) always to have been a result of tight bandaging or of sepsis from wound infection.

Suppuration occurs substantially only through wound infection, though Hutchinson does give a case of simple epiphyseal separation where abscess and necrosis occurred.

As to the secondary lesions of the fracture, there are almost no exact data. Certainly, stiffening of the fingers follows in certain cases, especially if they are not early mobilized, and this has been assumed a result of adhesions in the tendon-sheaths and compression by callus, but there seem to be no specimens to show this. Stiffening of the wrist is usually temporary, except as due to arthritis or bony deformity.

Various grades of secondary arthritis must exist, as evidenced by increased bony deposits about, and even in, the joints in museum specimens (see Fig. 3), and fresh distorted eburnated surfaces appear where the displaced radius meets the ulna, above the normal articulation; but what the processes in the joint are to which these appearances in the dry specimen correspond, what the clinical appearances are to which they correspond, there seem to be neither specimens nor examinations to show.

Such, then, are the lesions, the occurrence of which, as variations in the essential lesion, or as complications of the fracture, is attested by definite anatomical evidence.

As to the frequency with which these individual lesions occur, it is yet early to speak confidently. On this point the anatomical data are of secondary value, and reliance must be placed on the skiagraph and on the evidence of ordinary clinical examination. The only published series of skiagraphs of any considerable importance are those of Kahleyss and of Beck, covering sixty and forty-four cases respectively. Other series are of relatively small numbers. The writer has had oppor-

tunity to examine carefully some fifty or more unpublished X-ray negatives and prints from various sources. All these series are, however, open to various objections as a source of exact statistics.

First: Very few cases, relatively, have views in the two planes, and without both views it is often unwise to be too certain of details.

Second: Many skiagraphs are in themselves very imperfect, especially the earlier productions of a time when the technique was less reliable than to-day.

Third: Reproductions of skiagraphs for publication are usually very unsatisfactory.

For these reasons it seems unwise to attempt a detailed tabulation, and only the general deductions possible from the total will be attempted.¹ In general, the writer's conclusions would tally pretty closely with those of Kahleyss, whose X-ray series is the best published one at hand.

A majority of all cases seems to show some obliquity up and backward, but in most cases this is very slight. Sharp obliquity up and backward is distinctly unusual. Obliquity in the contrary direction seems to be an extreme rarity; the writer has not seen it shown in the skiagraph. From side to side the fracture line is usually nearly or quite transverse, but a moderate trend upward and outward is by no means unusual. Fractures running obliquely up and outward are not rare; the converse obliquity is, on the contrary, extremely uncommon. Separation of the radial styloid alone is by no means common, but hardly a rarity. The most usual height for the fracture is from three-quarters to one inch from the joint, and the great majority fall within or near this limit.

Comminution is frequent; it is not always easy to be certain of it unless there is spreading of the fragments; but it seems to occur in one-fourth to one-third of all cases, at least. (Kahleyss's estimate is 42 per cent.)

¹ Covering the series of Kahleyss, Beck, Freeman, Don, Haughton, Picard, Corson, and such unpublished plates and prints of his own and others as the writer has examined.

As to just what the lines of penetration into the joint are, the X-ray gives no information; but in a large number of the cases where the splitting of the posterior wall of the lower fragment is represented by a line, this line falls just about at the groove for the extensor secundi internodii pollicis. It cannot be asserted that this means a comminution in the fashion described by Bennett; but the findings are at least consistent with such a supposition. Few of the plates seem to warrant an interpretation of an anteroposterior splitting of the lower fragment, running clear through.

Displacement backward almost always occurs to some extent; displacement outward is frequent; but, save in the displacement of the outer portions of a smashed lower fragment, or in a few cases of marked upward and outward obliquity, it is rarely more than slight. Displacement forward is so rare, evidently, that it still remains a curiosity; and it seems an open question whether some of the considerable number of specimens of this deformity may not have had their origin in an over-zealous reduction. Displacement inward does occur (the writer has seen one such skiagraph), but it is a rarity, and the displacement trifling at that.

Entire absence of displacement is by no means rare.

Rotation backward is wellnigh universal when there is any displacement and occurs to a degree that seems in constant disproportion to what one feels in examining. A rotation of forty-five degrees or more, even in simple fractures, is not rare.

Rotation outward is the rule, though it is often present to slight degree only.

Impaction cannot be determined by the skiagraph; some shortening is common.

So far as the radius alone is concerned, the constantly recurring form is the transverse fracture about three-quarters inch up, simple, or if comminuted, then without much spreading of fragments, with moderate backward displacement and considerable backward rotation, without displacement, laterally, but with some rotation outward and upward.

As to the radio-ulnar connections, a broadening of the space between the bones, indicating ligamentous rupture, is present in a considerable number of cases; broadening of the wrist as a whole, whether from this cause, from comminution of the radius, or from tilting of the lower radial fragment up and out, is usually present in some degree.

As to the ulna, the familiar forward luxation is usual; practically, the only other lesion is the fracture of the ulnar styloid. This fracture occurs in a large proportion of the cases: according to Kahleyss 78 per cent; the skiagraphs examined by the writer show 40 per cent.; those of Beck 16 per cent. The average of all X-rays available gives just 50 per cent.

The forms of fracture of the styloid have already been considered.

Separations of the radial epiphysis, and especially separations without any notable displacement and incomplete separations seem to be rather common. On the other hand, fractures of one or both bones close to the intact epiphyseal line seem not to be unusual, especially in small children.

A consideration of the pathology of Colles's fracture would not be complete without some notice of the experimental evidence, unsatisfactory as it is.

The writer has, in his turn, attempted the experimental solution of the etiology of the various fracture-forms, and the number of more or less carefully recorded experiments in the literature is very large;¹ but it cannot be said that the evidence is conclusive. The different forces applied and the different conditions under which force is applied do not express themselves with any constancy in the fractures produced. It can, at most, only be said that such and such a lesion may be produced in this or that way, not that it is a constant result of a given procedure.

Transverse fractures were obtained by forced hyperex-

¹In the majority of cases, however, the results of experiments are imperfectly recorded; hence, of fourteen articles recording experiments, there is little more in the way of data than is here put down.

tension by Schmit, by forced extension and by forced flexion as well by Hamilton.

Fractures oblique up and backward seem to be produced (experimentally) only by blows on the hand, or on the elbow with the hand fixed (so Weir and Kahleyss). Schmit, Weir, and Kahleyss all produced comminution by this or similar means (lever pressure) in a number of experiments: hyperextension does not produce comminution. Impaction, too, is to be produced only by a blow (Schmit). Fractures of the radial styloid and fractures oblique up and outward have been produced by hyperextension (Schmit, Lecomte, Hamilton). Separation of the epiphysis may be a result of hyperextension¹ (Schmit) or of forced flexion (Schmit, Roberts). Chipping of the posterior edge may result from hyperextension (Weir, Kahleyss), or may result from a blow on the elbow with the hand fixed (Kahleyss).

Fractures of the ulnar styloid seem to belong only to the smashing force applied in the axis of the bone, though Roberts produced this lesion in one case by forced flexion. Longitudinal fissures have been produced by Bennett by direct violence (rolling the wrapped-up wrist under his heel), while Kahleyss produced transverse fissures of the back surface by forced flexion.

Looked at from the side of the method used:

Force applied in the axis of the arm with mallet or lever produced fracture oblique up and back, or less usually chipping posteriorly, and produced comminution and impaction in some cases.

Forced hyperextension produced most inconstant lesions, including especially fractures of the radial styloid and of the anterior edge, as well as transverse fracture.

The writer's own experiments,² however, show as a result of hyperextension in each case an oblique fracture upward and

¹ This requires, as the writer has repeatedly found, only a minimal force in the new-born cadaver, and probably not much in the early years.

² Published in detail in the *Journal of the Boston Society of the Medical Sciences*, 1898, Vol. ii, p. 171.

forward,—a simple lifting off of the anterior portion of the joint surface by the anterior ligament, as Lecomte and Hamilton also found in some of their experiments. In applying force in the axis of the arm, however, whether by lever or with the mallet, the results were less constant; namely, two fractures oblique, up and back, three transverse (two of them comminuted, one "Barton's" fracture, and one irregular splitting of no definite type). There were two fractures of the ulnar styloid, both the result of force applied in the axis of the bone. Both the comminuted transverse fractures were split into the joint in the way described by Bennett.

The most obvious conclusion to be drawn from this showing is that the mechanism is neither simple nor constant; and this is borne out when we consider the evidence of clinical histories, for there are at least two recorded cases where a fall on the back of the hand produced a Colles's fracture with backward displacement (Cameron, Hamilton),¹ and other cases (Hennequin, and Roberts's Cases I and XI) where force received on the palmar side produced anterior displacement of the fragment. In practice, Colles's fracture is a result of falls on the palm of the hand, or, in some cases, of force applied to hand and elbow.² It seems probable that the prime factor is the crushing force taking effect at the weakest portion of the bone. Undoubtedly hyperextension alone may cause the fracture; at all events some fracture of the wrist, as in two cases by Voillemier and one of Jones where the fingers and the fore part of the palm received all the force. Probably hyperextension plays some part, a subordinate one, in many cases of fracture. The epiphyseal separations are probably more often so caused.

Comminution is evidently a result of the splitting of the lower fragment by the upper, and the break occurs more usu-

¹ In a case of the writer's with moderate silver-fork deformity—showing in the X-ray a comminuted transverse fracture—there was also a distinct history of a fall on the back of the hand.

² In the German mines this fracture is said to be frequently a result of crushing in this direction, the arm being caught between ore-cars as the miner is shoving one forward.

ally at the posterior edge where the greatest penetration is, and through the weakest parts of this region.

Probably fractures of the radial styloid and fractures oblique up and outward are produced by marked abduction of the hand at the moment of impact. In this way, too, as well as by the driving upward of the lower fragment, the rupture of the radio-ulnar ligaments, including the triangular fibro-cartilage, is to be explained.

The fracture of the ulnar styloid is evidently not a result of pull on the triangular cartilage (for both may give way together), but of the lateral ligament. The writer is inclined to suspect, however, that some cases of fracture of the ulnar styloid result from contact with the ground, when the ulna is luxated forward at the moment of impact.¹

Now that the lesions occurring, their relative frequency and their probable causation have been considered, it would be most desirable to fix on certain broad types of Colles's fracture (since we can no longer speak of one type), types perhaps representing associated lesions due in each case to some peculiarity in the vulnerating forces. The writer has studied the data in vain for any satisfactory basis for such classification.

There is, perhaps, a type without marked deformity, a simple transverse fracture representing the simple giving way of an old bone under slight violence (for Schnitz has demonstrated most satisfactorily the decreased power of resistance to fracture of the wrists of older subjects); there is a converse type, a comminuted fracture with much displacement and much damage to ligaments, representing the giving way of a bone that is young and strong and yields only to excessive trauma; there is, perhaps, also a type of fracture probably caused by impact with the hand in abduction or impact on the ulnar side of the palm, where there is upward and outward obliquity of the fracture line, or a fracture of the radial styloid, and more frequently than in other sorts, a fracture of the ulnar styloid; but these types are by no means constant in detail and by no means cover all cases.

¹ Tillmanns speaks of it as being crushed off.

On the whole, it is perhaps as sound simply to describe the lesions, and not to try to classify them in groups on the basis of such knowledge as we now have.

REFERENCES.

- Beck: Medical News, 1898, Vol. lxxii, p. 231.
 Bennett: British Medical Journal, 1880, Vol. i, p. 759; Ibid., 1892, Vol. i, p. 902; Dublin Journal of the Medical Society, 1881, Vol. lxxi, p. 372; Transactions of the Royal Academy of Medicine, Ireland, Vol. ix, 1890, p. 457, and Vol. x, 1891-92, p. 322.
 Bruns: Langenbeck's Archiv, 1881, Band xxvii, 240.
 Brünnner: London Medical Record, 1886, p. 298.
 Bulteau: Bull. de la Soc. Anatom., 1877, p. 382.
 Callender: Glasgow Medical Journal, 1878, Vol. x, p. 197.
 Cock: Guy's Hospital Reports, Third Series, Vol. vii, p. 262.
 Don: British Medical Journal, 1897, Vol. i, p. 797.
 Dufpuytren: Quoted by Kahleyss.
 Erichsen: Science and Art of Surgery, Sixth edition, Vol. i, p. 326 (quoted by Lucas).
 Falkson: Centralb. f. Chirurgie, 1885, Band xii, 913.
 Flower: Holmes's System of Surgery, Vol. ii, p. 801.
 Freeman: ANNALS OF SURGERY, 1897, Vol. xxv, p. 471.
 Gerard-Marchant: Rev. d'Orthopedie, 1894, v, 147.
 Golobiewski: Vrtljhrsch. f. gerichtl. Med., 1894, vii, 122.
 Gordon: Fractures of the Lower End of the Radius, London, 1875.
 Hall: New York Medical Journal, 1886, Vol. xliii, p. 414.
 Hamilton: Fractures and Dislocations, and New York Medical Record, 1881, Vol. xx, p. 107.
 Haughton: British Medical Journal, 1897, Vol. i, p. 797.
 Hecht: Münchner med. Wochensch., 1894, No. 32.
 Helferich: Fractures and Dislocations.
 Hennequin: Rev. de Chir., 1894, Vol. xiv.
 Hunt: Annals of Anatomy and Surgery (Brooklyn), 1881, p. 110.
 Hutchinson: British Medical Journal, 1866, June 30, and Illustrated Clinical Surgery, Vol. xix, Plate LXXI.
 Jones: Liverpool Medico-Chirurgical Journal, 1885, Vol. v, p. 430.
 Kahleyss: Deutsche Zeitsch. f. Chir., 1897, 533.
 Lenoir: Arch. Gén. de Méd., 1839.
 Letenneur: Bull. de la Soc. Anat., 1839, xiv, 162.
 Löbker: Deutsche med. Wochensch., 1885, No. 27.
 Lucas: Guy's Hospital Reports, 1883-84, Vol. xxvii.
 McGraw and Walker: Annals of Anatomy and Surgery (Brooklyn), 1881.
 Moore: New York Medical Record, 1880, Vol. xvii, p. 305.
 Ogston: British Medical Journal, 1876, Vol. ii, p. 298.
 Packard: Ashhurst International Cyclopædia of Surgery, Vol. vii, and American Journal of the Medical Sciences, 1879.

- Di Paoli: Del distacco traumatico delle epifisi, Torino, 1882 (cited by Poland).
- Picard: Thèse de Paris, No. 457, 1898.
- Pilcher: New York Medical Record, 1878, Vol. ii, p. 74.
- Pilcher: Fracture of the Lower Extremity of the Radius, 1897.
- Poland: Traumatic Separation of the Epiphyses, London, 1898.
- D'Arcy Power: Transactions of the Pathological Society, London, 1887, Vol. xxxviii, p. 250.
- Roberts: American Journal of the Medical Sciences, 1897, p. 10, and "Study, etc., of Fracture of Lower End of Radius," Philadelphia, 1897.
- Rutherford: Glasgow Medical Journal, 1891, Vol. xxxv, p. 312.
- Schmit: Thèse de Paris, 1878.
- Schwartz: Rév. d'Orthopédie, 1898, Sept. 1.
- Shattock: Transactions of the Pathological Society, London, 1889-90, Vol. xli, p. 236.
- Smith: Fractures in Vicinity of Joints, 1847.
- Stehr: Bruns's Beiträge, 1889, Band v, 595.
- Stimson: Fractures and Dislocations, p. 449.
- Thomas: British Medical Journal, June 2, 1897.
- Voillemier: Arch. Gén. de Méd., 1839, vi, 401.
- Westbrook: Annals of Anatomy and Surgery (Brooklyn), 1881, p. 113.
- Wight: Pathologist (Brooklyn), 1881, p. 15, and Medical and Surgical Reporter, 1880, Vol. xliii, 141.